NOAA National Centers for Environmental Information Topo-Bathymetric Digital Elevation Models: East Florida

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Introduction

This report summarizes the creation of a suite of tiled digital elevation models (DEMs) developed for East Florida in 2018 by the NOAA National Centers for Environmental Information (NCEI; Fig. 1). This work was funded by NOAA National Weather Service (NWS) to support the Consumer Option for an Alternative System to Allocate Losses (COASTAL) Act.

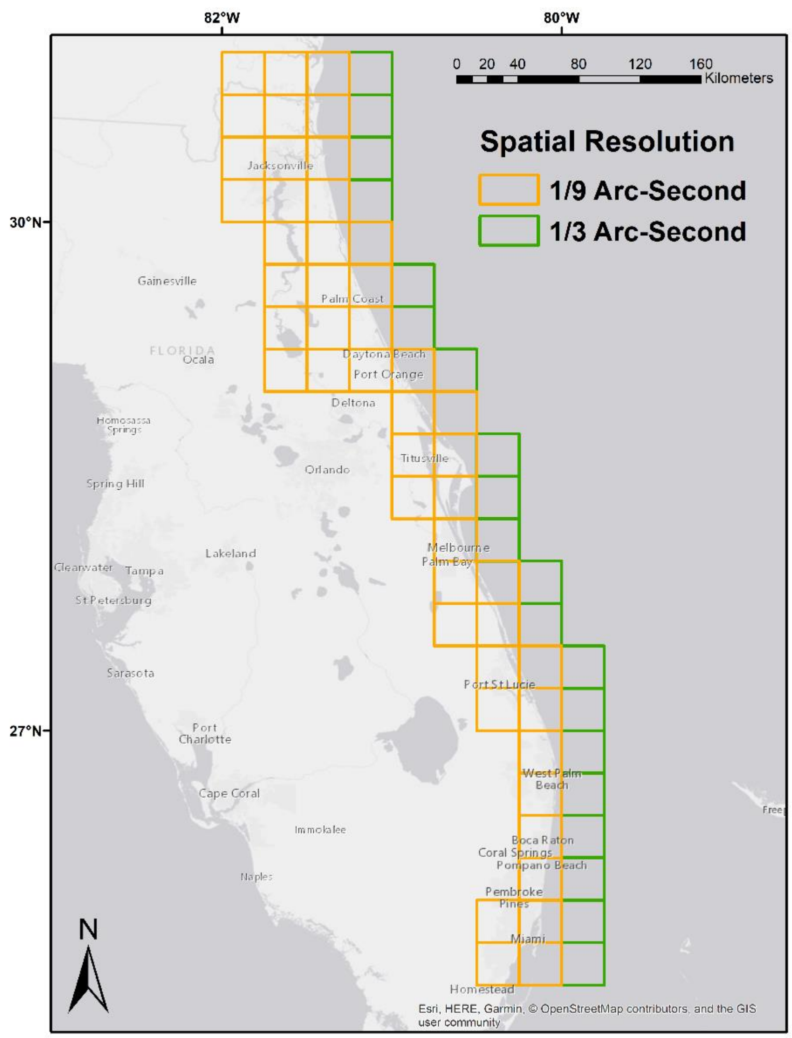


Figure 1. Spatial Extent of the 2018 NOAA NCEI East Florida Tiled DEM suite. Note that only 1/9 arc-second DEM tiles integrate topography and bathymetry.

The DEMs have been built according to specifications developed jointly by NOAA NCEI and the United States Geological Survey (USGS) to better define a consistent elevation mapping framework for the nation (Eakins et al., 2015; Table 1). Overall, 68 tiled DEMs were created in the area of interest: 48 tiles were created at the highest resolution of 1/9 arc-seconds, and 20 were created at a resolution of 1/3 arc-seconds. Only 1/9 arc-second DEMS tiles integrate topography and bathymetry. The DEM tiles represent best available data at the time of their creation; the intent is to update specific tiles as new source data becomes available. The utilization of a tiling scheme in developing the DEMs is intended to improve data management during source data processing, as well as facilitate targeted DEM updates.

Table 1. DEM specifications of the East Florida Tiled DEM suite (from Eakins et al., 2015)

Projection	Local UTM Zone		Geographic				
Cell size	1 m	3 m	1/9 arc-sec	1/3 arc-sec	1 arc-sec	3 arc-sec	9 arc-sec
Offshore coverage	1 nm	3 nm	3 nm	24 nm	500-m depth	200 nm	ECS, LMEs
Grid registration	Pixel						
Horizontal datum	NAD 83						
Vertical datum	NAVD 88				Sea level		
Edge precision	3 m		0.01 degrees (36 arc-sec)				
Elevation precision	0.01 m	0.1 m				1 m	
Multi-temporal	yes		No				
Surface type	Bare earth						
Restrictions	None/Public						

The final integrated 1/9 arc-second topography-bathymetry DEM tiles and 1/3 arc-second bathymetry and topography tiles are referenced horizontally to the North American Datum of 1983 (NAD83) and vertically to the North American Vertical Datum of 1988 (NAVD88).

<u>Data Processing</u>

Original source topographic and bathymetric data were collected by a variety of agencies, including federal, state and local governments. Source data were obtained in a variety of different formats and referenced to disparate horizontal and vertical datums (Table 2).

Table 2. Source datasets used in the creation of the NOAA NCEI East Florida Tiled DEM suite

Source Dataset	Data Type	Acquisition Date	Horizontal Datum/Projection	Vertical Datum	Notes
City of Palm Coast	Topographic Lidar	2017	NAD83 (2011) State Plane Florida East	NAVD88 (geoid 12b)	
Coastal Georgia Regional Development Center	Topographic Lidar	2010	NAD83	NAVD88 (geoid 12a)	
Florida Division of Emergency Management (FDEM)	Topographic Lidar	2004	NAD83	NAVD88 (geoid 12a)	Flagler County
Florida Division of Emergency Management (FDEM)	Topographic Lidar	2007	NAD83	NAVD88 (geoid 12a)	Brevard, Clay, Duval, Herbert, Indian River, Nassau, and Putnam

					Counties; South Florida Blocks
Florida Fish and Wildlife Research Institute Biscayne Bay	Bathymetric Lidar (gridded)	2008	NAD83	NAVD88 (geoid03)	
Lake County Board of County Commissioners	Topographic Lidar	2007	NAD83	NAVD88 (geoid 12a)	
Martin County	Topographic Lidar	2016	NAD83	NAVD88 (geoid 12b)	
Miami-Dade County Information Technology Department (ITD)	Topographic Lidar	2015	NAD83	NAVD88 (geoid 12b)	
NOAA National Geodetic Survey (NGS)	Topographic-Bathymetric Lidar	2017	NAD83	NAVD88 (geoid 12b)	Florida Keys Outer Reef Block 04
NOAA National Ocean Service Hydrographic Survey Data	Bathymetric Soundings and Gridded Bathymetry	1870-2017	NAD83	MLLW	
NOAA NCEI Multibeam Database	Multibeam Bathymetric Soundings	1990-2015	WGS84	Instantaneous Water Level	
Southwest Florida Water Management District (SWFWMD)	Topographic Lidar	2003	NAD83	NAVD88 (geoid 12a)	Marion County
St. Johns County Geographic Information Systems	Topographic Lidar	2013	NAD83 HARN State Plane Florida East Feet	NAVD88 (geoid 12b)	
St. Johns River Water Management District (SJRWMD)	Topographic Lidar	2009-2012	NAD83	NAVD88 (geoid 12b)	Orange, Putnam, and Seminole Counties
U.S Army Corps of Engineers (USACE)	Topographic-Bathymetric Lidar	2016-2017	NAD83	NAVD88 (geoid 12b)	2016 National Coastal Mapping Program (NCMP) Topobathy Lidar: Florida East Coast, 2017 Post-Matthew Topobathy Lidar: Southeast Coast (VA, NC, SC, GA, FL), 2017 USACE FEMA Topobathy Lidar: Florida East

					Coast, Florida Keys, and Collier County
U.S Army Corps of Engineers (USACE)	Bathymetric Soundings	2008-2017	NAD83 Florida State Plane	MLLW	Channel Condition Surveys
U.S Geological Survey (USGS)	National Elevation Dataset (NED; gridded)	1999-2013	NAD83	NAVD88	NED 1/3 Arc-Sec utilized in areas without topographic lidar
Volusia County Public Works Department	Topographic Lidar	2006	NAD83	NAVD88 (geoid 12a)	

All source data were converted to a common horizontal (NAD83) and vertical (NAVD88) reference system using the Geospatial Data Abstract Libraries (GDAL) utilities and the NOAA VDatum software utility, respectively. The vertical datum of bathymetric datasets referenced to Mean Lower Low Water (MLLW) were converted to the NAVD88 (Geoid12B definition for consistency with topographic data already referenced to NAVD88. No conversion occurred among topographic datasets referenced to NAVD88 Geoid12A, as Geoid12A and Geoid12B are equivalent, except in Puerto Rico. Multibeam bathymetry, which in most cases was obtained uncorrected with regard to the water level at the time of data acquisition, was left as such (i.e., Instantaneous Water Level). The magnitude of the differences between various tidal datums and NAVD88 was assumed to be well within the measurement uncertainty associated with the multibeam data (Appendix I).

All data were converted to a common data format (ASCII xyz) in preparation for gridding. If a dataset was obtained in a raster format, it was resampled using a bilinear resampling algorithm to match the target spatial resolution of the affected tile, then converted to ASCII xyz using GDAL. All data was reviewed and evaluated for internal and external consistency with adjacent data. Anomalies in datasets were removed through visual inspection and automated filtering.

MB-System's 'mb-grid' utility was used for all gridding processes. A tensioned thin-plate spline algorithm was used to interpolate depth values in pixels within the DEM extent that were unconstrained by elevation measurements. Constrained pixels were assigned a final elevation value based on the Gaussian weighted average of the input source elevation measurements.

For all tiles with bathymetric data, an initial bathymetric surface was created using the source bathymetry (See Carignan et al., 2011 for a detailed description of the process).

For tiles that did not integrate bathymetry and topography, the smoothed bathymetric surface is the final product. In cases where both bathymetry and topography are mapped, the smoothed bathymetric surface was converted to ASCII xyz and included as an additional dataset to create the final seamless bathy-topo elevation surface using MB-System's 'mb-grid' utility. The bathymetric surface was initially gridded at a spatial resolution of 1/3 arc-seconds, then resampled to the target resolution of 1/9 arc-seconds for integrated bathymetric-topographic tiles.

Final DEM tiles were qualitatively evaluated to identify anomalous data points, as well as compared with imagery and NOAA Raster Nautical Charts. If necessary, persistent anomalies were cleaned from the input source data and the DEM tile was re-generated using the previously described processes. No quantitative analysis was performed to assess the accuracy of the DEMs, although this continues to be an area of active research at NCEI (see Amante and Eakins, 2016 and Amante, 2018).

For more information, contact dem.info@noaa.gov

References:

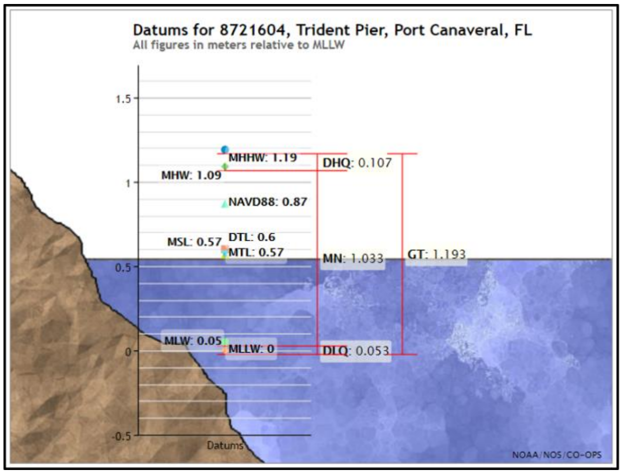
Amante, C.J., 2018. Estimating Coastal Digital Elevation Model Uncertainty. *Journal of Coastal Research*, In-Press.

Amante, C.J. and Eakins, B.W., 2016. Accuracy of interpolated bathymetry in digital elevation models. In: Brock, J.C., Gesch, D.B., Parrish, C.E., Rogers, J.N., and Wright, C.W. (eds.), *Advances in Topobathymetric Mapping, Models and Applications*. Journal of Coastal Research, Special Issue, No. 76, pp.122-133.

Carignan, K.S.; Taylor, L.A.; Eakins, B.W.; Caldwell, R.J; Friday, D.Z.; Grothe, P.R. and Lim, E., 2011. Digital Elevation Models of Central California and San Francisco Bay: Procedures, Data Sources and Analysis. *NOAA Technical Memorandum NESDIS NGDC-52*, 49p.

Eakins, B.W., Danielson, J.J., Sutherland, M.G., McLean, S.J., 2015. A framework for a seamless depiction of merged bathymetry and topography along U.S. coasts. *Proceedings of the U.S. Hydro Conference* (National Harbor, MD, March 16-19), 10p.

Appendix I – Schematic of measured vertical datum offsets at NOAA tide gauge 8721604



Elevations on Mean Lower Low Water

Station: 8721604, Trident Pier, Port Canaveral, FL
T.M.: 0
Status: Accepted (Jul 19 2011)
Epoch: 1983-2001
Units: Meters
Datum: MLLW
Control Station: 8720030 Fernandina Beach, FL

Datum	Value	Description
MHHW	1.193	Mean Higher-High Water
MHW	1.086	Mean High Water
MTL	0.569	Mean Tide Level
MSL	0.573	Mean Sea Level
DTL	0.596	Mean Diurnal Tide Level
MLW	0.053	Mean Low Water
MLLW	0.000	Mean Lower-Low Water
NAVD88	0.873	North American Vertical Datum of 1988
STND	-5.480	Station Datum
GT	1.193	Great Diurnal Range
MN	1.033	Mean Range of Tide
DHQ	0.107	Mean Diurnal High Water Inequality
DLQ	0.053	Mean Diurnal Low Water Inequality